

12. Although we did not find the *Bacillus typhosus* in any oysters obtained from the sea or from the markets, yet in our experimental oysters inoculated with typhoid we were able to recover the organism from the body of the oyster up to the tenth day. We show that the typhoid bacillus does not increase in the body or in the tissues of the oyster, and our figures indicate that the bacilli perish in the intestine.

13. Our experiments showed that sea-water was inimical to the growth of the typhoid bacilli. Although their presence was demonstrated in one case on the twenty-first day after addition to the water, still there appeared to be no initial or subsequent multiplication of the bacilli.

14. In our experiments in washing infected oysters in a stream of clean sea-water the results were definite and uniform; there was a great diminution or total disappearance of the typhoid bacilli in from one to seven days.

15. The colon group of bacilli is frequently found in shell-fish as sold in towns, and especially in the oyster; but we have no evidence that it occurs in mollusca living in pure sea water. The natural inference that the presence of the colon bacillus invariably indicates sewage contamination must, however, not be considered established without further investigation.

16. The colon group may be separated into two divisions: (1) those giving the typical reactions of the colon bacillus, and (2) those giving corresponding negative reactions, and so approaching the typhoid type; but in no case was an organism giving all the reactions of the *B. typhosus* isolated. It ought to be remembered, however, that our samples of oysters, although of various kinds and from different sources, were in no case, so far as we are aware, derived from a bed known to be contaminated or suspected of typhoid.

17. We have shown also the frequent occurrence, in various shell-fish from the shops, of anaërobic spore-bearing bacilli giving the characteristics of the *B. enteritidis sporogenes* recently described by Klein.

18. As the result of our work, we make certain recommendations as to the sanitary regulation and registration of the oyster beds, and as to quarantine for oysters imported from abroad.

“On the Formation of Multiple Images in the Normal Eye.” By
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[PLATE 5.]

It is well known that a small bright object for which the eye is not accommodated often presents a multiform appearance, the number of separate images perceived varying in different cases from about six to

fifteen. In Helmholtz's 'Physiological Optics,' drawings are given illustrative of the phenomena exhibited by a luminous point when the conjugate focus is situated a little in front of or a little behind the retina. A narrow luminous line such as that formed when a spectro-scope slit is held before a flame or other bright background may become similarly multiplied. These and other allied phenomena are believed to arise from the suture-like radial lines, six or more in number, which occur upon the two surfaces of the crystalline lens.

It is also known that as the result of disease or malformation of the eye, the patient may habitually see several images of single objects. But in the course of a careful search among physical and physiological publications, in which Dr. Dawson Turner, of Edinburgh, has most kindly assisted me, I have been unable to find any reference to certain curious phenomena of vision which attracted my notice in the year 1897, and which form the subject of the present communication. It appears that under suitable conditions a normal healthy eye can see hundreds of independent images of a single point, an effect which probably results from the cellular structure of the lenses and the membranes associated with them.

In the earlier observations, the object consisted of a small bright disc. Several different discs were employed, their diameters ranging from 0.5 mm. to 8 mm., and other details were also varied, but (when the circumstances were suitably modified) the results were in all cases of the same nature. It will be convenient to describe the procedure actually carried out in a particular experiment; but, except as furnishing a rough guide for the repetition of the experiment, no special importance must be attached to the distances mentioned; they vary greatly for different individuals, and from time to time even for the same eye.

The condenser of a lantern was covered with two sheets of glass, the one ground and the other deep red. In front of these was placed a brass plate, in the middle of which was drilled a hole $\frac{1}{12}$ inch (2 mm.) in diameter. Inside the lantern was an incandescent electric lamp of 25-candle power. The observer, standing with his left eye at a distance of about 2 feet from the hole in the plate, first covered the hole with a concave lens of 11 inches (28 cm.) focal length, held in his hand, and then slowly moved the lens towards his eye. When the lens was some four or five inches away from the hole, the outline of the little bright disc began to appear multiple; there seemed, in fact, to be a number of little discs almost, but not quite exactly, superposed. As the lens approached the eye, the images became gradually more and more widely dispersed, and when the eye was reached, they had become completely separated. There now appeared to be seven bright discs—a central one surrounded by six others, their arrangement being fairly symmetrical; these were backed by an irregular luminous haze

of nearly circular outline. If the light was made stronger, each of the circumferential discs acquired a pointed tail, directed radially outwards, and the whole appeared like a six-rayed star. So far there is little or nothing new in the observation.

The observer then gradually moved backwards, still holding the lens at his eye; the outer discs at once began to elongate radially, and each soon became resolved into two or more, the approximate symmetry of the figure being still retained. When the distance from the eye to the hole was 3 feet, the number of images that could be counted was about twenty, and the appearance presented was happily likened, by an expert person who confirmed my observations, to that of a large unripe blackberry. If an orange-yellow glass were substituted for the dark red one, the stronger illumination again gave rise to the development of tails, and the blackberry became transformed into a beautiful flower. At 4 feet distance the images had increased to about forty, which was nearly the greatest number that could be counted with any degree of certainty. But, while becoming much less easily distinguishable, they still obviously continued to multiply. At 25 feet there was seen a mottled luminous patch streaked with a few bright lines, evidently corresponding with the sutures of the crystalline lens. These bright lines were found to consist of overlapping images of the round hole, and traces of many similar images could be detected in different parts of the mottled patch.

The above described effects can be observed equally well and with but little modification when the lens employed is convex instead of concave; indeed, any one who is skilled in the management of his eyes may dispense with the lens altogether.

I have tried to describe the phenomena as seen with my left eye. With the right eye they are of the same general character, but differ in details; in particular, the separate images first seen are less symmetrically arranged, and their number appears to be eight instead of seven. The observations in question would be found difficult or impossible by a novice in optical experiment, partly on account of his inability to keep his eye in a definite state of accommodation, but chiefly perhaps because he would not recognise what he saw.

I thought that the observations might be rendered easier if the source of light had a more distinctive and conspicuous form than that of a simple circle. Experiments were, therefore, made with a semi-circular hole, and this was in some respects an improvement; but far better results were afterwards obtained by using as a source of light the horseshoe-shaped filament of an electric lamp, screened by a coloured glass. When such a lamp was looked at through a lens, concave or convex, of about 6 inches focal length, from a distance of a few feet, the roughly oval patch of luminosity formed upon the retina appeared to be made up of a crowd of separate images of the filament, some

being brighter than others, as represented in fig. 1. The number was apparently few when the observer was near the lamp, and greatly increased as he retired from it, or moved the lens further from his eye.

It occurred to me that the analysis of the luminous field would be facilitated if the attention could be confined to a small portion of it. With this object in view I interposed an adjustable slit taken from a spectroscope, between the eye and the lens, and adjusted its width by trial. When the round hole in the brass plate was viewed through this arrangement it appeared like a string of bright beads, arranged not in a perfectly straight line but somewhat sinuously. A slight movement of the slit in a direction perpendicular to its length produced a curious wavelike motion of the beads.

By sufficiently increasing the distance between the source of light and the eye, perhaps as many as twenty-four or twenty-five bright spots might be made to appear in the row, but they could not be counted with certainty. At a greater distance, or with a lens of shorter focus, the spots became indistinct and blurred.

The appearance presented by the filament of the electric lamp, when seen through the slit, made $\frac{1}{80}$ inch (0.3mm.) wide, and a convex lens of 5 inches (12.7 cm.) focus is very well imitated in figs. 2, 3, and 4, which show the effect when the slit is in horizontal, vertical, and intermediate positions. The imitation was produced by photographing the lamp by means of a lens covered with two layers of gauze, the one containing seventy-five meshes to the linear inch, the other fifty; a slit $\frac{1}{25}$ inch (1 mm.) in width was placed before the lens.

Another attempt was made to count the number of images in a row. The whole of the filament was screened from view, except a very short portion of one limb, which was viewed from a distance of about 8 feet (2.5 m.) through the spectroscope slit, and a convex lens of 5 inches (12.7 cm.) focus. A sheet of coloured glass was interposed as before, and care was taken to hold the slit in such a position that the length of the row was a maximum. According to the estimates of five different observers, the number of images ranged from twenty to thirty. One excellent observer counted them several times, his greatest total being twenty-seven, and his smallest twenty-three. Exact enumeration is perhaps impossible, for though at the first glance one receives the impression that the number of images is quite definite, and probably about twenty-five, closer examination shows that it is often very difficult to localise the line of demarcation between successive images.

The number of images in a row varies with the dilatation of the pupil. If a lighted candle be held near the eye with which the observation is not being made, the pupil of the observing eye contracts sympathetically, and two or three images disappear from each end of the row.



FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.

If the distance between the eye and the incandescent filament is made much more than 8 feet, or if a lens of shorter focus is employed, the multiple images become blurred and indistinct; at a distance of 20 feet with a lens of 3 inches (7.6 cm.) focal length, the separate images appeared to have coalesced, but the band of light was crossed by a very large number of hazy dark lines at right angles to its length and at fairly equal distances apart.

Thinking that the original images had been resolved into still simpler elements, I endeavoured to ascertain how many elements were developed from each image. Fixing my attention upon a conspicuous image near the end of the row, I moved a convex lens slowly forwards in front of the slit, and carefully watched the changes which occurred. It was found very difficult to follow them satisfactorily, but the conclusion arrived at was that the space corresponding to a single image was ultimately crossed by from fifteen to twenty dark lines; hence, assuming twenty-five images, the total number of elements would be four or five hundred.

Taking the diameter of the pupil when feebly illuminated to be $\frac{1}{5}$ inch, these latter observations seem to indicate some fairly regular anatomical structure in or near the crystalline lens, and composed of cells measuring about $\frac{1}{2500}$ inch (0.01 mm.) in length or breadth. It has been suggested to me that the cause may be found in the endothelium on the anterior surface of the lens, the cells of which are polyhedral and flattened, and about 0.02 mm. in diameter. Their dimensions appear to be too large, but perhaps the agreement is as close as could be expected.

I do not know of any structure sufficiently coarse-grained to account for the images of which twenty-five or thereabouts occur in a row. The mesh of a network which would explain these should be about $\frac{1}{125}$ inch (0.2 mm.) in length, and nothing of the kind is, I believe, to be found in the eye. Probably, however, the effect is a composite, or rather a differential one, like that of the two pieces of gauze used in photographing the lamp. If light passed through two or more superposed nets having fine meshes, dark bands would generally be produced, which would take the form of a network of a coarser mesh than those of the nets themselves—possibly much coarser, as would be the case if the two nets were nearly alike in structure.

The seven or eight images referred to in the description of the first observation are, as before mentioned, undoubtedly due to the sections or sutures of the lens.



FIG. 1.



FIG. 2.



FIG. 3.



FIG. 4.